

PB90-149840

Superfund Ground Water Issue: Accuracy of Depth to
Water Measurements. 2nd in Series of Issue Papers

(U.S.) Robert S. Kerr Environmental Research Lab., Ada, OK

Aug 89



U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO. EPA/540/4-89/002	2.	3. RECIPIENT'S ACCESSION NO. PB90-149840
4. TITLE AND SUBTITLE ACCURACY OF DEPTH TO WATER MEASUREMENTS	5. REPORT DATE August, 1989	
	6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) Jerry T. Thornhill	8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Robert S. Kerr Environmental Research Laboratory Post Office Box 1198 Ada, OK 74820	10. PROGRAM ELEMENT NO. TEKY1A	11. CONTRACT/GRANT NO. In-House/Contract #68-C8-00
12. SPONSORING AGENCY NAME AND ADDRESS Robert S. Kerr Environmental Research Lab. U.S. Environmental Protection Agency Post Office Box 1198 Ada, OK 74820	13. TYPE OF REPORT AND PERIOD COVERED 2nd in Series of Issue Papers	14. SPONSORING AGENCY CODE EPA/600/15
15. SUPPLEMENTARY NOTES Project Officer: John E. Matthews, FTS: 743-2233		
16. ABSTRACT The accuracy of depth to water measurements is an issue identified by the Regional Superfund Ground Water forum as a concern of Superfund decision-makers as they attempt to determine direction of ground-water flow, areas of recharge or discharge, the hydraulic characteristics of aquifers, or the effects of manmade stresses on the ground-water system. The wetted graduated steel tape, electrical and air line methods are discussed along with frequency of measurements. The graduated steel tape method is considered to be the most accurate for measuring the water level in nonflowing wells. ←		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field Group
REPRODUCED BY U.S. DEPARTMENT OF COMMERCE NATIONAL TECHNICAL INFORMATION SERVICE SPRINGFIELD, VA. 22161		
18. DISTRIBUTION STATEMENT RELEASE TO THE PUBLIC	19. SECURITY CLASS (This Report) UNCLASSIFIED	21. NO. OF PAGES 4
	20. SECURITY CLASS (This page) UNCLASSIFIED	22. PRICE



Superfund Ground Water Issue

Accuracy of Depth to Water Measurements

Jerry T. Thornhill

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange up-to-date information related to ground-water remediation at Superfund sites.

Accuracy of depth to water measurements is an issue identified by the Forum as a concern of Superfund decision-makers as they attempt to determine directions of ground-water flow, areas of recharge or discharge, the hydraulic characteristics of aquifers, or the effects of manmade stresses on the ground-water system.

Perhaps the most extensive investigation into methods for measuring water levels in wells has been conducted by the U.S. Geological Survey. The U.S.G.S., in conjunction with 32 other federal agencies put together a "National Handbook of Recommended Methods for Water-Data Acquisition," which includes an entire section on water-level measurements. The following discussion is based on that document.

For further information, contact Jerry T. Thornhill, RSKERL-Ada, FTS 743-2310.

The graduated steel tape (wetted-tape method), the electrical measuring line, and the air line are the most common tools for manually measuring water level in nonflowing wells.

Graduated Steel Tape

The graduated steel tape method is considered to be the most accurate for measuring the water level in nonflowing wells. Steel surveying tapes in lengths of 100, 200, 300, 500 and 1,000 feet are commonly used. The tapes, up to 500-foot

lengths, are mounted on hand-cranked reels; the 1,000-foot tapes usually required a motor-driven tape drive. A slender weight, usually made of lead, is attached to the ring at the end of the tape to insure plumbness and to permit some feel for obstructions. The choice of a suitable weight, i.e., lead, stainless steel, etc. is dictated by the water-quality parameters of interest in a specific study. Lead weights are used so that if the weight should fall off the tape in a well that has a pump, the soft lead would be less likely to damage the pump. The weight is attached in such a way that if it becomes lodged in the well, the tape can still be pulled free.

The lower few feet of the graduated tape is chalked by pulling a piece of blue carpenter's chalk across the tape. When the chalk becomes wet, a line of color change between the dry and wet chalk denotes the length of tape immersed in water. The tape footage is read at the measuring point, and at the water mark on the tape. The difference between these two readings is the depth to water below the measuring point.

Submergence of the weight and tape may temporarily cause a water-level rise in wells or piezometers having very small diameters. This effect can be significant if the well is in materials of very low hydraulic conductivity. Under dry surface conditions, it may be desirable to pull the chalked part of the tape rapidly to the surface before the wetted part of the tape dries and read the water mark before rewinding the tape onto the reel. This is accomplished by pulling the tape from the well by hand, being careful not to allow it to become kinked. In cold regions, rapid withdrawal of the tape from the well is necessary before the wet part freezes and becomes difficult to read.

Garber and Koopman (1968, p. 3-6) describe corrections for effects of thermal expansion of tapes and of stretch due to the



Superfund Technology Support Centers for Ground Water

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suspended weight of the tape and plumb weight. Errors resulting from these effects can become significant at high temperatures and for measured depths in excess of 1,000 feet.

As a standard of good practice, the observer should make two measurements. If two measurements of static water level made within a few minutes do not agree within about 0.01 or 0.02 foot (generally regarded as the practical limit of precision) in observation wells having a depth to water of less than two hundred feet, continue to measure until the reason for the lack of agreement is determined or until the results are shown to be reliable. Where water is dripping into the hole or covering its wall, it may be impossible to get a good water mark on the chalked tape.

Unless the well is equipped with an access pipe that is placed to eliminate the possibility of lowering the tape into the pump impellers, the graduated-tape method should not be used to measure pumping levels in wells.

After each well measurement, the portion of the tape that was wetted should be disinfected to avoid contamination of other wells.

A simple and reliable method for measuring the depth to water in observation holes between 1-1/2 and 6 inches in diameter is a steel tape with a popper. The popper is a metal cylinder 1 to 1-1/2 inches in diameter and 2 to 3 inches long with a concave undersurface and is fastened to the end of a steel tape. The popper is raised a few inches and then dropped to hit the water surface, where it makes a distinct "pop." By adjusting the length of the tape, the point at which the popper just hits the surface is rapidly determined (Bureau of Reclamation, 1977).

Electrical Methods

Many types of electrical instruments have been devised for measuring water levels; most operate on the principle that a circuit is completed when two electrodes are immersed in water. Some instruments consist of a single conductor that is lowered into the well where the metal well casing is used as the second conductor. More commonly, a two-conductor cable and special probe are used. Various forms of electrolytic cells using two electrodes of dissimilar metals have been used, but current is more commonly supplied by batteries.

Ordinarily, two-conductor electric tapes are 500-foot long and are mounted on a hand-cranked reel that contains space for the batteries and some device for signaling when the circuit is closed. Electrodes are generally contained in a weighted probe that keeps the tape taut while providing some shielding of the electrodes against false indications as the probe is being lowered into the hole. The electric tapes generally are marked at 5-foot intervals with clamped-on metal bands.

Before lowering the probe in the well, the circuitry can be checked by dipping the probe in water and observing the indicator. The probe should be lowered slowly into the well until contact with the water surface is indicated. The electric tape is marked at the measuring point and partly withdrawn; the distance from the mark to the nearest tape band is measured and added to (or subtracted from) the band reading to obtain the depth to water. It is good practice to take a second or third

check reading before withdrawing the electric tape from the well.

The tape should not rub across the top of the casing because the metal bands can become displaced; consequently, placement of the bands should be checked frequently with a steel tape.

Electric tapes are more cumbersome and inconvenient to use than the wetted-tape method, and they normally give less accurate results. In some situations, however, they are superior. Where water is dripping into the hole or covering its walls, it may be impossible to get a good water mark on the chalked tape. In wells that are being pumped, particularly with large-discharge pumps, the splashing of the water surface makes consistent results by the wetted-tape method impossible. Where a series of measurements are needed in quick succession, such as in aquifer tests, electric tapes have the advantage of not having to be removed from the well for each reading. Electric tapes are also safer to use in pumping wells because the water is sensed as soon as the probe reaches the water surface and there is less danger of lowering the tape into the pump impellers.

Independent electric tape measurements of static water levels using the same tape should agree within ± 0.04 feet for depths of less than about 200 feet. At greater depths, independent measurements may not be this close. For a depth of about 500 feet, the maximum difference of independent measurements using the same tape should be within ± 0.1 foot.

It is especially important to check the electric line length by measuring with a steel tape after the line has been used for a long time or after it has been pulled hard in attempting to free the line. Some electric lines, especially the single line wire, are subject to considerable permanent stretch. In addition, because the probe is larger in diameter than the wire, the probe can become lodged in a well. Some operators attach the probe by twisting the wires together by hand and using only enough electrical tape to support the weight of the probe. In this manner, the point of probe attachment is the weakest point of the entire line. Should the probe become "hung in the hole," the line may be pulled and breakage will occur at the probe attachment point, allowing the line to be withdrawn.

Air Line Methods

The air line method is especially useful in pumped wells where water turbulence may preclude using more precise methods. A small diameter air-type tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air (compressor, bottled air, or tire pump) is used to purge the water from the tube. The pressure, in pounds per square inch (psi), needed to purge the water from the air line multiplied by 2.31 (feet of water or one psi) equals the length in feet of submerged airline. The depth to water below the center of the pressure gage can be easily calculated by subtracting the length of air line below the water surface from the total length of the air line (assuming the air line is essentially straight). Accuracy depends on the precision to which the pressure can be read.

The air line and any connections to it must be airtight throughout its entire length. If the line is broken or leaky, large errors may

occur. A long-term increase in air line pressure may indicate a gradual clogging of the air line. A relatively sudden decrease in air line pressure may indicate a leak or break in the air line. Air line pressures that never go above a constant low value may indicate that the water level has dropped below the outlet orifice of the air line. To minimize the effect of turbulence, the lower end of the air line should be at least five feet above or below the pump intake.

Frequency of Measurements

The frequency for measuring water levels in wells depends on the nature of the aquifer under investigation, and on the problems that are to be solved. Thus, the frequency of measurement should be adjusted to the circumstances; i.e., water-level measurements at a given location should be made at approximately the same time of day whenever possible.

At the beginning of an investigation, when details of the ground-water system are not yet known, water levels are commonly made at regular intervals; for example, 10 times a month for water-table conditions and 5 times a month for artesian conditions at key observation sites (Ground-Water Studies, UNESCO).

The reader is referred to the references for detailed handling on the subject of frequency of measurement in various applications.

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